The origin of Disks and Spheroids in simulated galaxies

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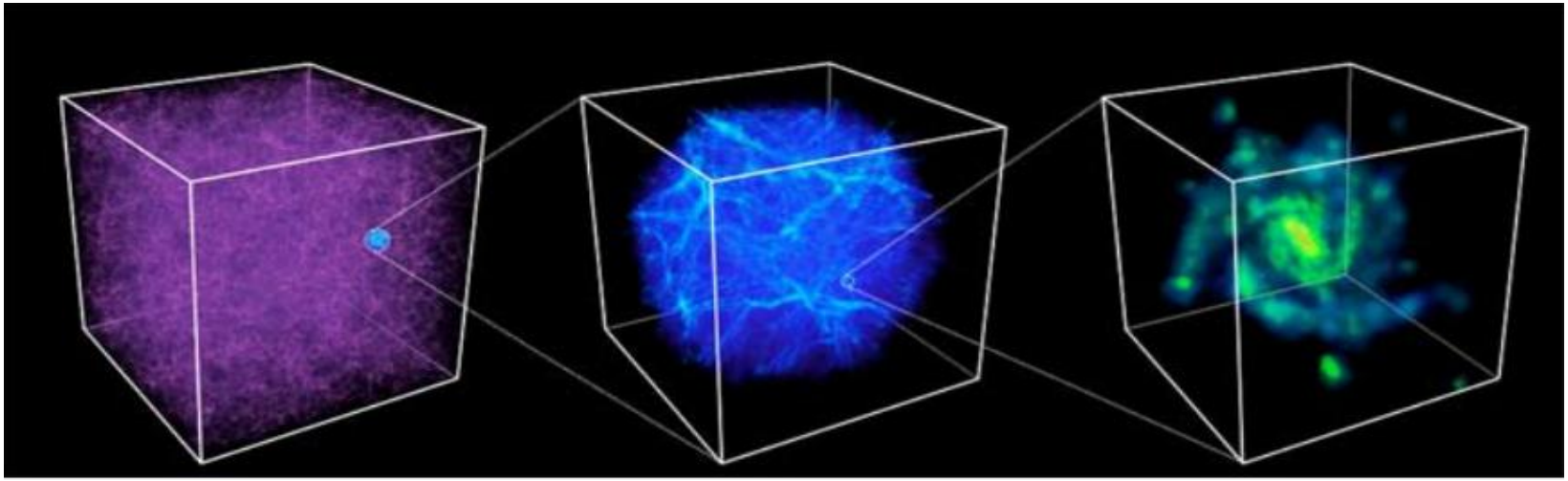
Simulations: Galaxies-Intergalactic Medium Interaction Calculation (GIMIC; Crain et al. 2009)

Redshift z=1.5

Crain et al. 2009



Milennium simulations
L=500 h^{-1} Mpc

1 of 5 regions
L ~ 50 h^{-1} Mpc

GIMIC galaxy
L ~ 50 h^{-1} kpc

GADGET3 code

Cosmological parameters $\Omega_m = 0.25$, $\Omega_\Lambda = 0.75$, $\Omega_b = 0.045$, $n_s = 1$, $\sigma_8 = 0.9$, $h = 0.73$.

$m_{gas} = 1.45 \times 10^6\ h^{-1}\ M_s$

$M_{drk} = 6.6 \times 10^6\ h^{-1}\ M_s$

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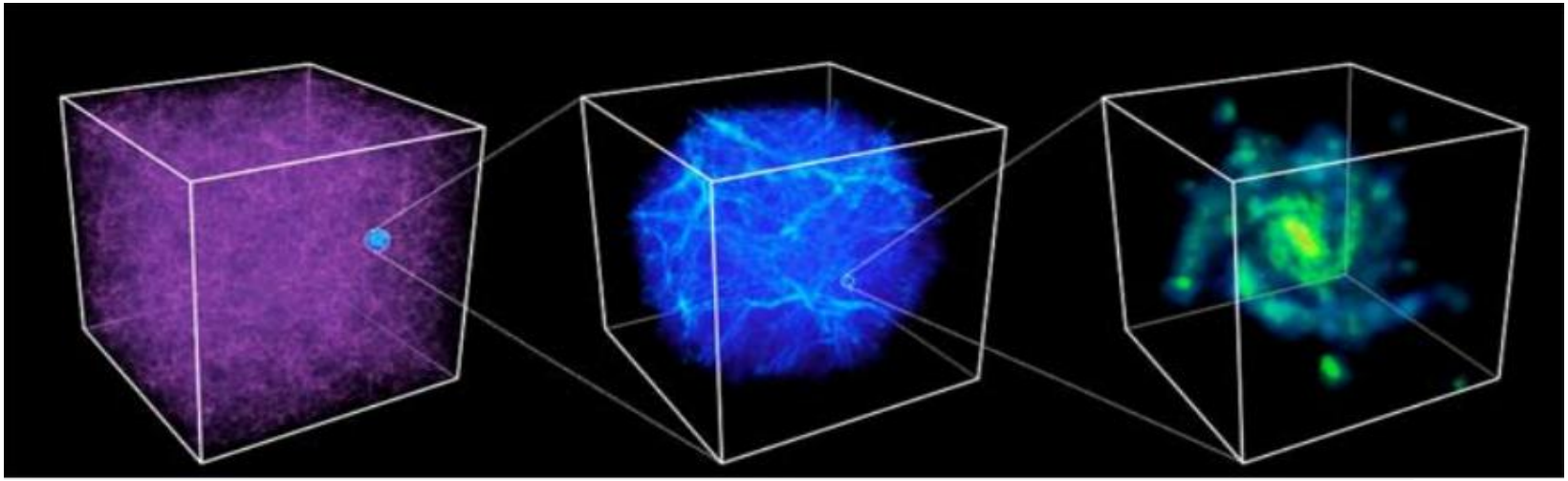
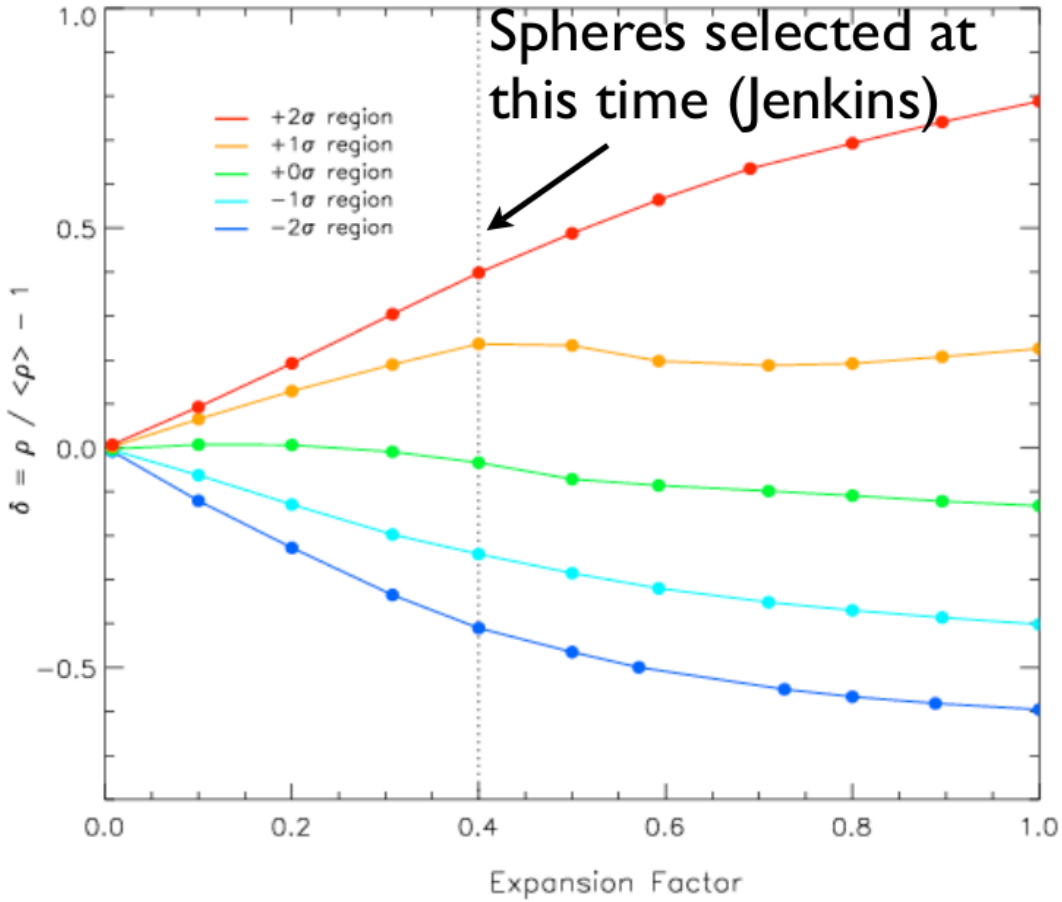


Region	x $[h^{-1}\,\mathrm{Mpc}]$	y $[h^{-1}\,\mathrm{Mpc}]$	z $[h^{-1}\,\mathrm{Mpc}]$	Comoving radius $[h^{-1}\,\mathrm{Mpc}]$	N (int. res)	N (high res)
-2σ	153.17	347.90	424.81	18	2.23×10^7	1.78×10^8
-1σ	387.91	316.48	113.46	18	2.80×10^7	2.24×10^8
0σ	271.94	108.29	107.45	18	3.44×10^7	2.75×10^8
$+1\sigma$	179.51	379.22	196.64	18	4.30×10^7	3.44×10^8
$+2\sigma$	233.10	139.30	387.38	25	1.24×10^8	N/A



Crain et al. 2009

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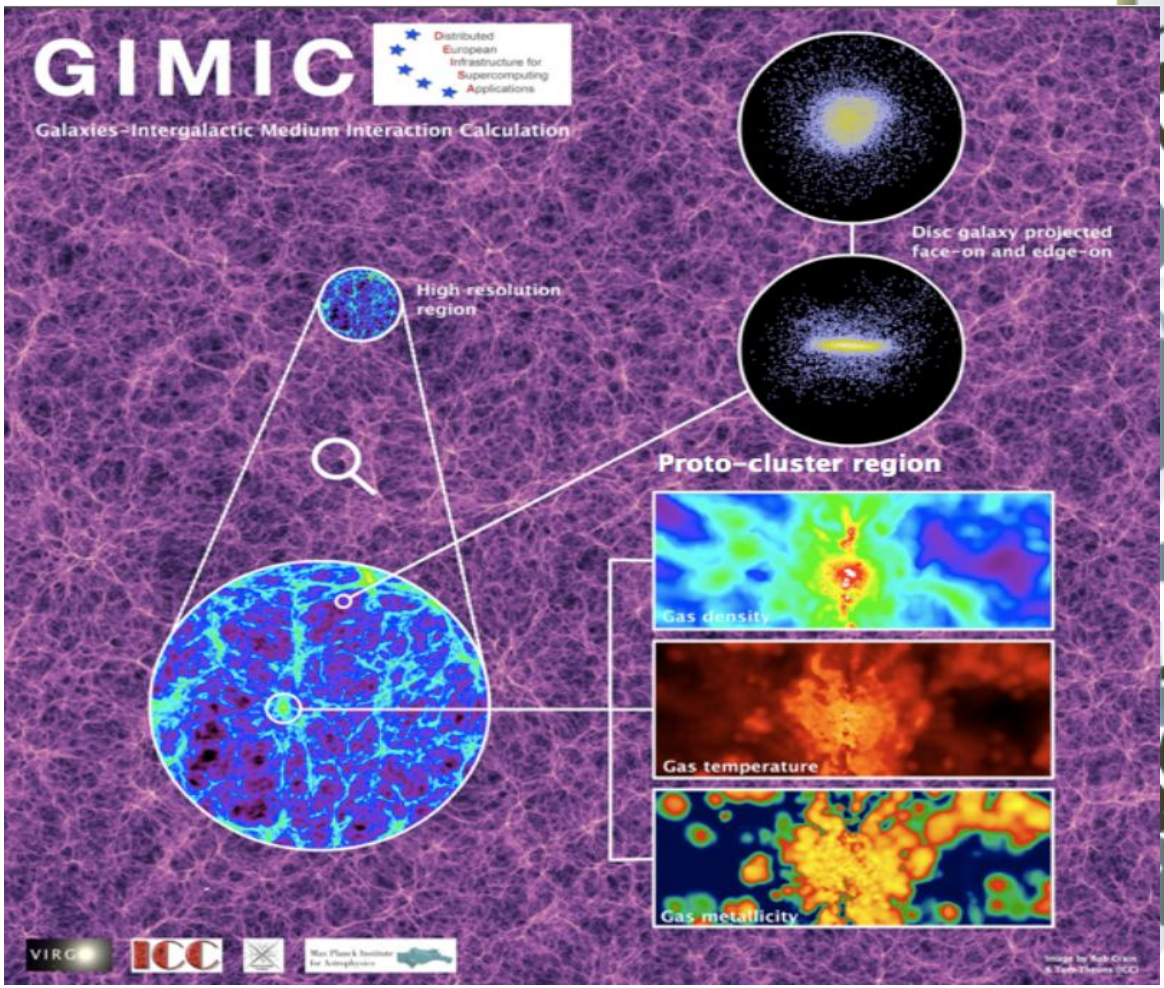
Motivation for GIMIC:

- include (very) large-scale structure
- good numerical resolution yet able to reach redshift z=0
- formation of unusual objects (massive cluster, deep void)
- estimate statistical properties

Objectives:

- Galaxy properties and environment
- IGM properties and environment
- Interaction galaxies/IGM



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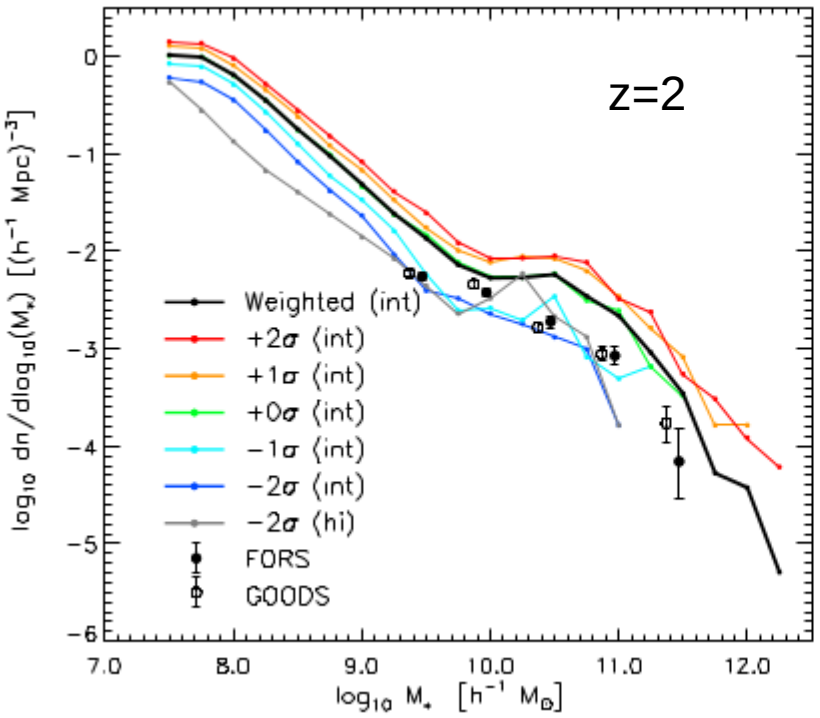
Too many galaxies of very low mass
Too many galaxies of very high mass
And not enough galaxies of intermerdiate mass

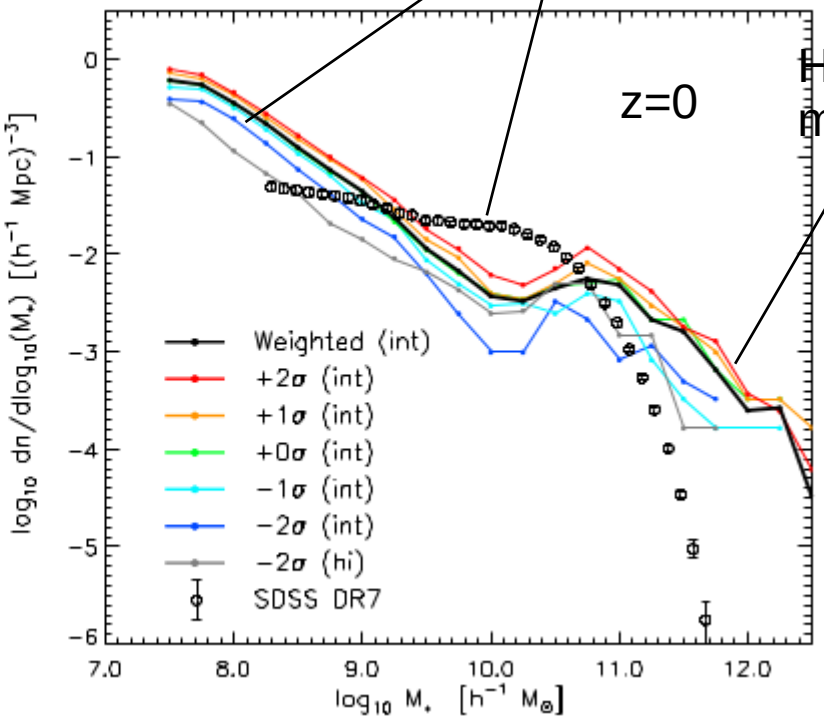
Stellar Mass function

Crain et al. 2009

Galactic winds

Heating mechanism



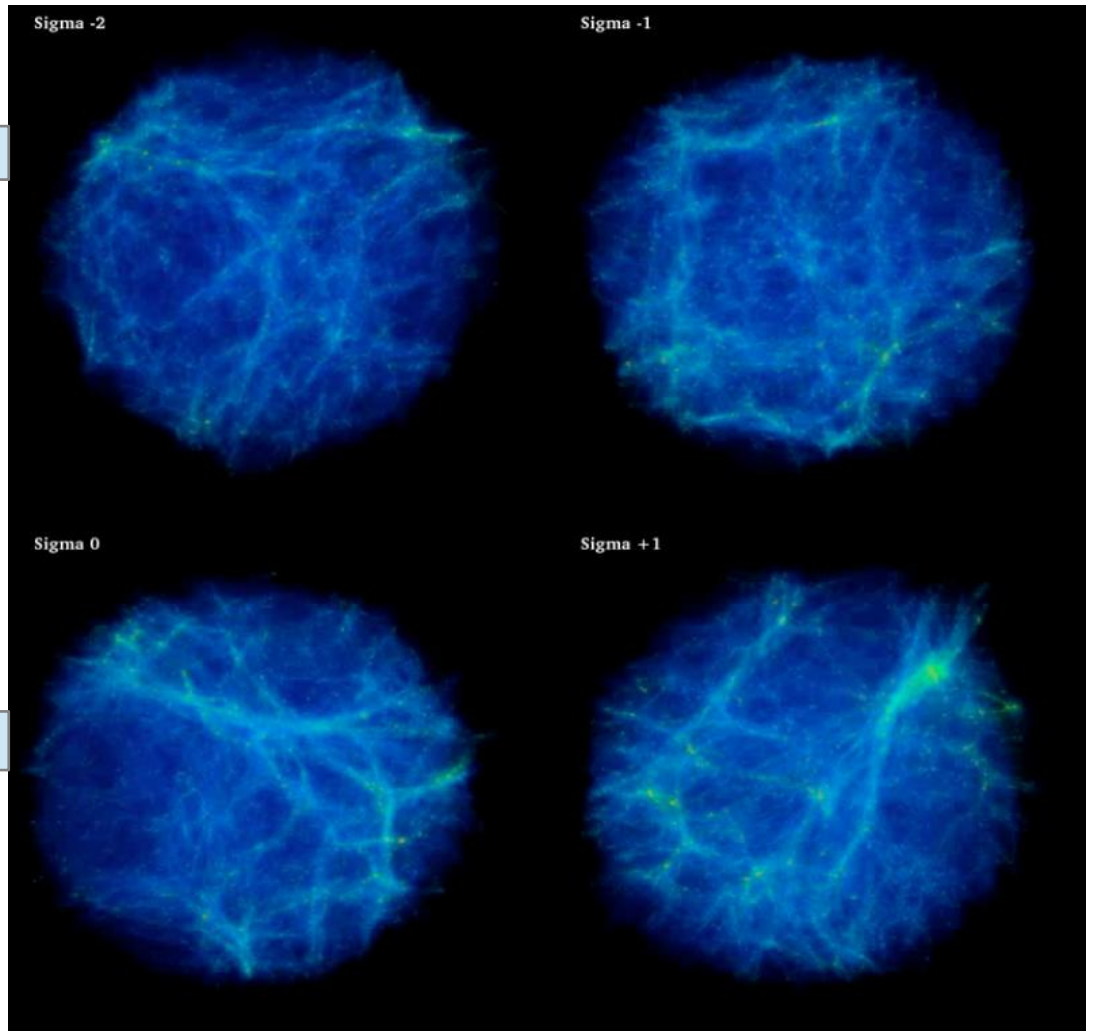


Sample

38 halos

$0.5 < M_{200}/10^{12}\ h^{-1}\ M_{\odot} < 1.5$ (z=0)

62 halos



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Simulated galaxy morfology

Fraction of kinetic energy invested in ordered rotation

$$\kappa_{\rm rot} = \frac{K_{\rm rot}}{K} = \frac{1}{K}\sum \frac{1}{2} m \left(\frac{j_z}{R}\right)^2 .$$

κ_{rot} = 1 ⇒ disk with perfect circular motion

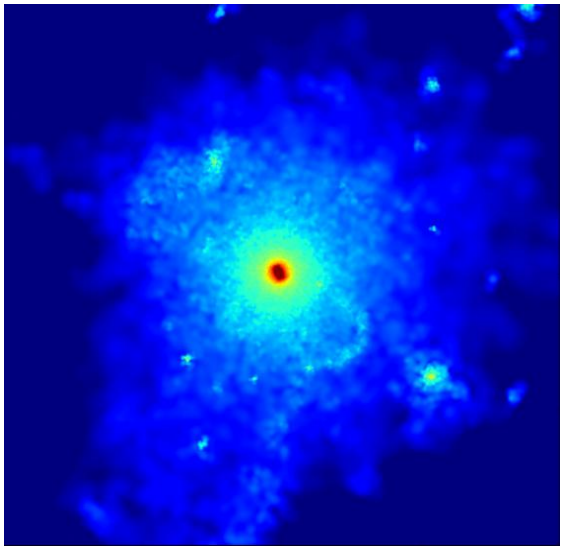
κ_{rot} =0 ⇒ non-rotating system

κ_{rot} < 0.5 ⇒ spheroid-dominated

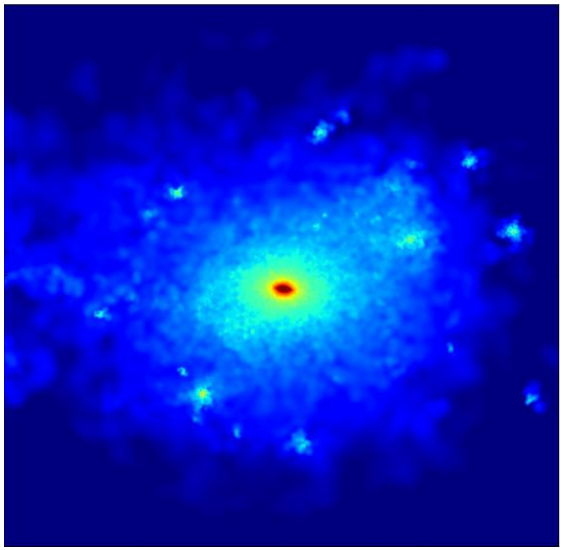
κ_{rot} > 0.7 ⇒ disk-dominated

$\kappa_{rot} = 0.35$

Face on

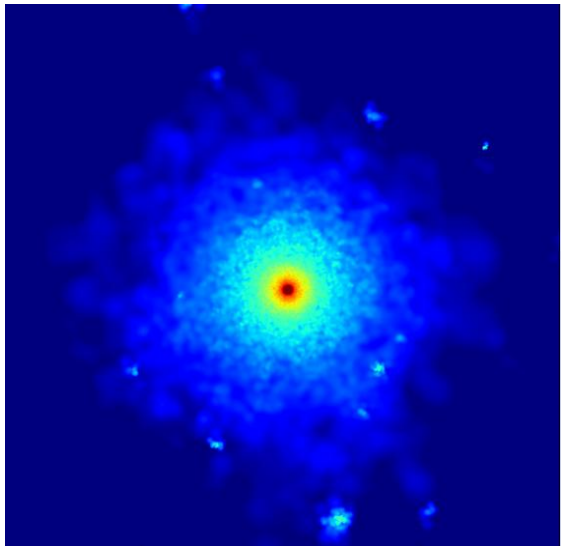


Edge on



$\kappa_{rot} = 0.55$

Face on



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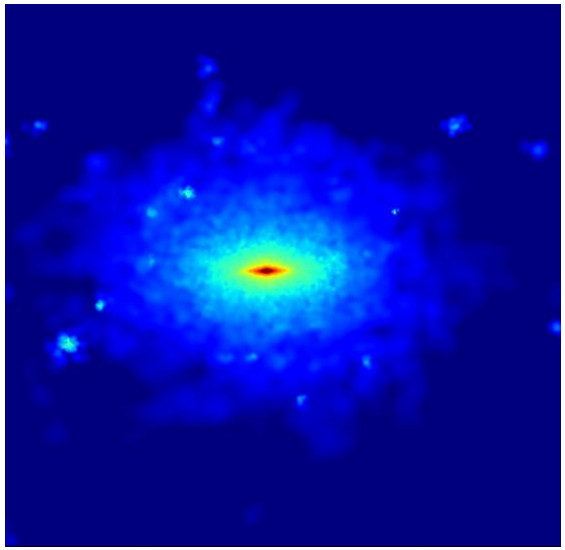
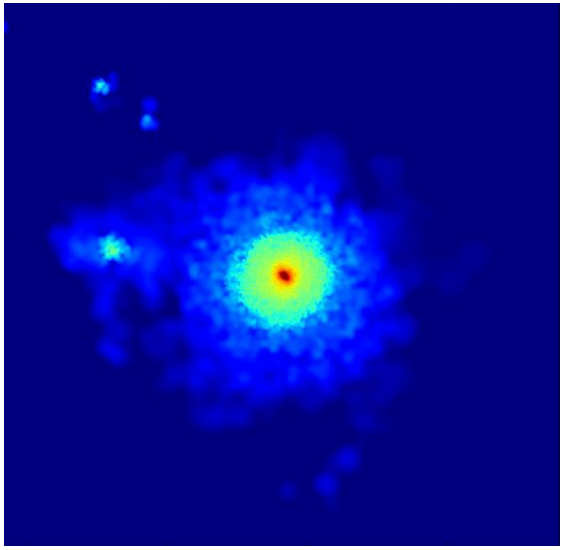
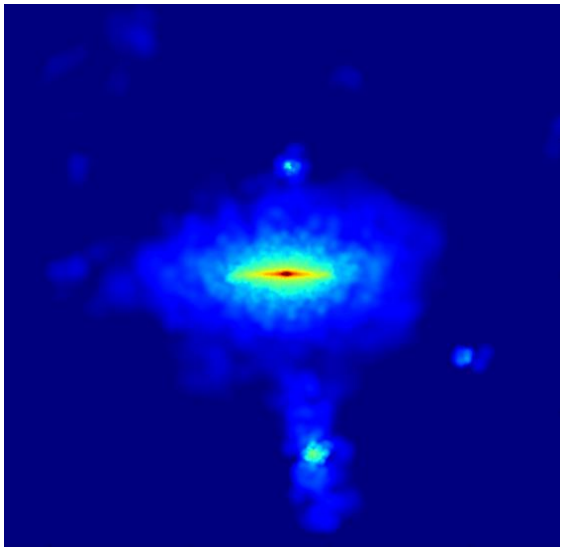


$\kappa_{rot} = 0.7$

Face on



Edge on



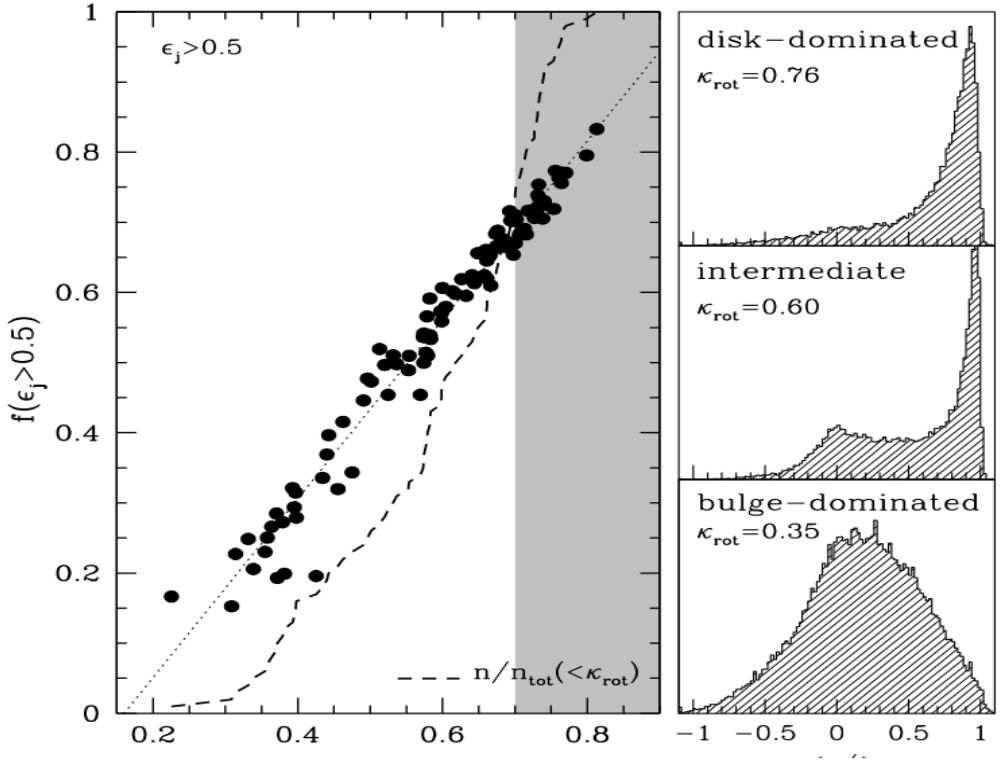
Simulated galaxy morfology

Circularity parameter: $\varepsilon_j(E)=j_z/j_{circ}(E)$

$-1 \leq \varepsilon_j(E) \leq 1$

Sales et al. 2012

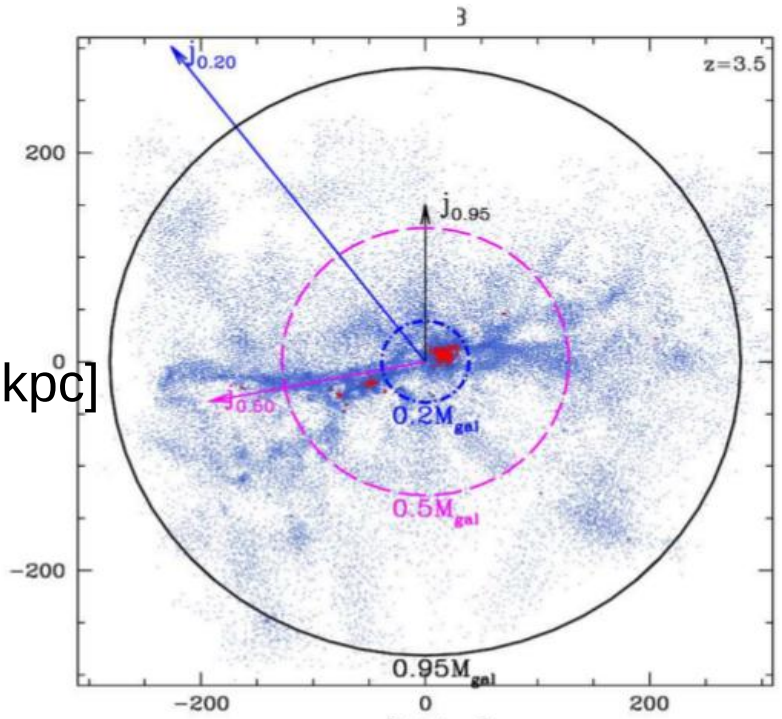
Fraction of particles with $\varepsilon_j(E) > 0.5$



The origin of simulated galaxy morphologies

Sales et al. 2012

Turnaround Time

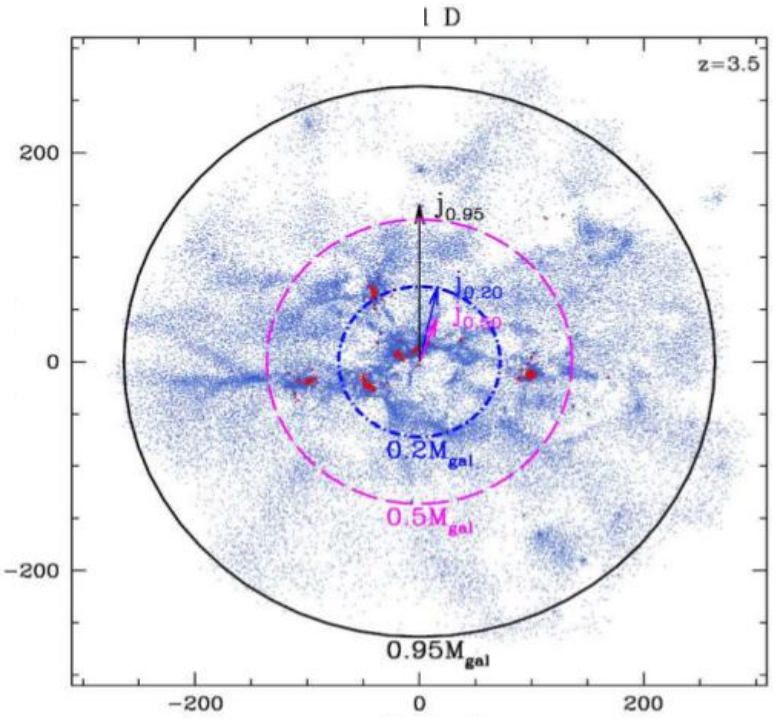


Z [h^{-1} kpc]

X [h^{-1} kpc]

Spheroid galaxy (z=0)

κ_{rot} = 0.47



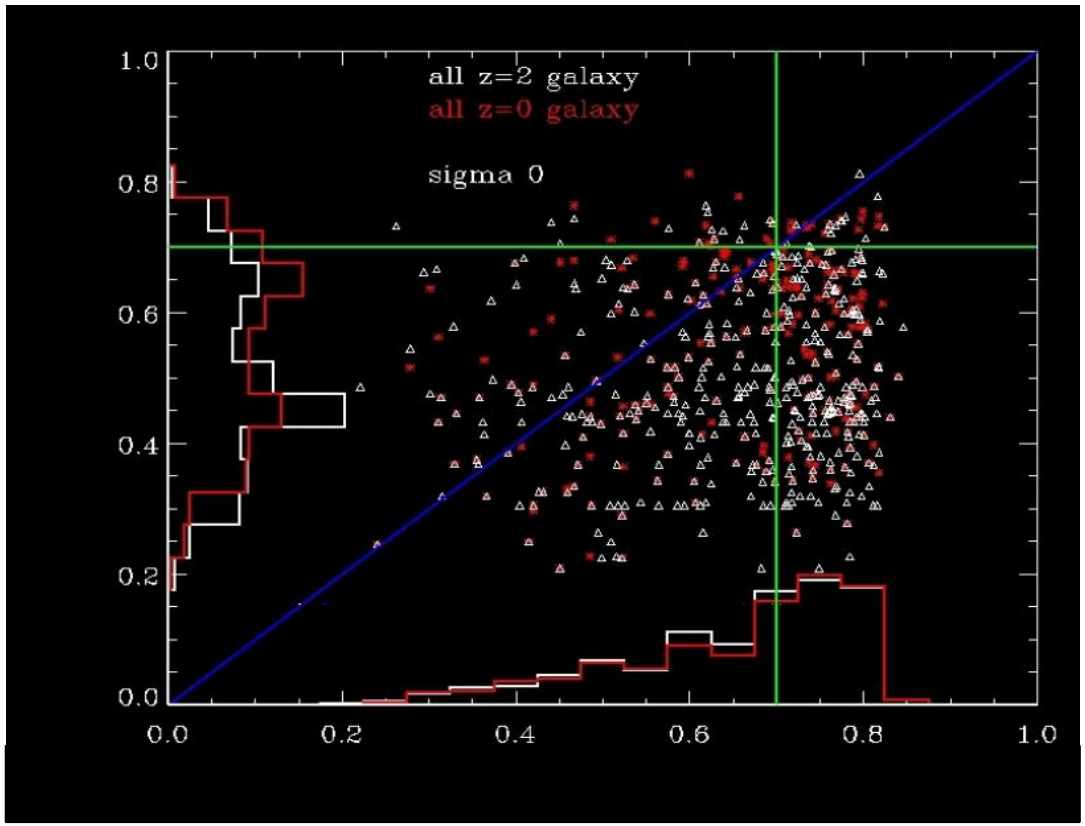
X [h^{-1} kpc]

Disk galaxy (z=0)

κ_{rot} = 0.76

κ_{rot} evolution

Ismael Ferrero



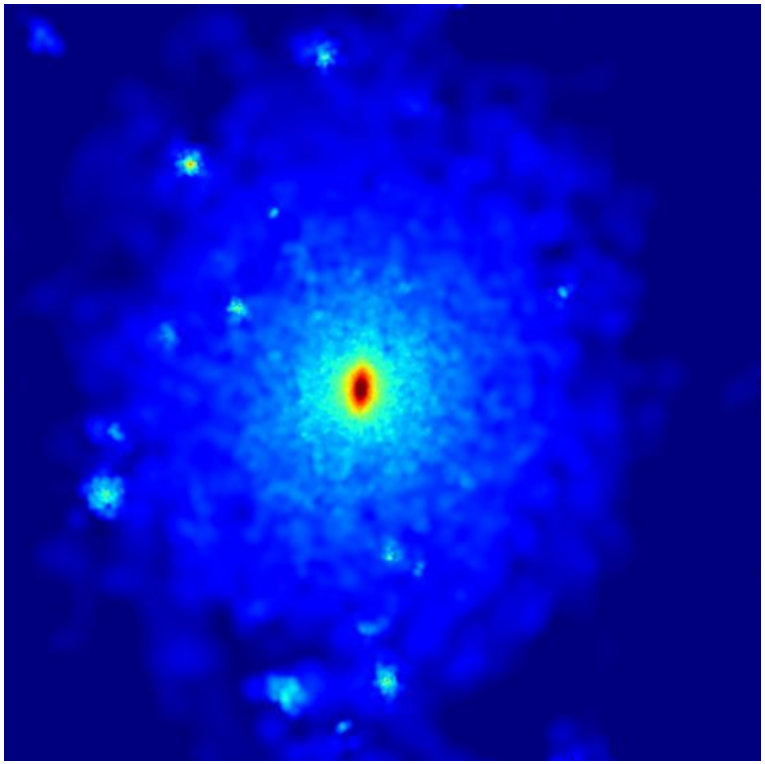
κ_{rot} (z=0)

κ_{rot} (z=2)

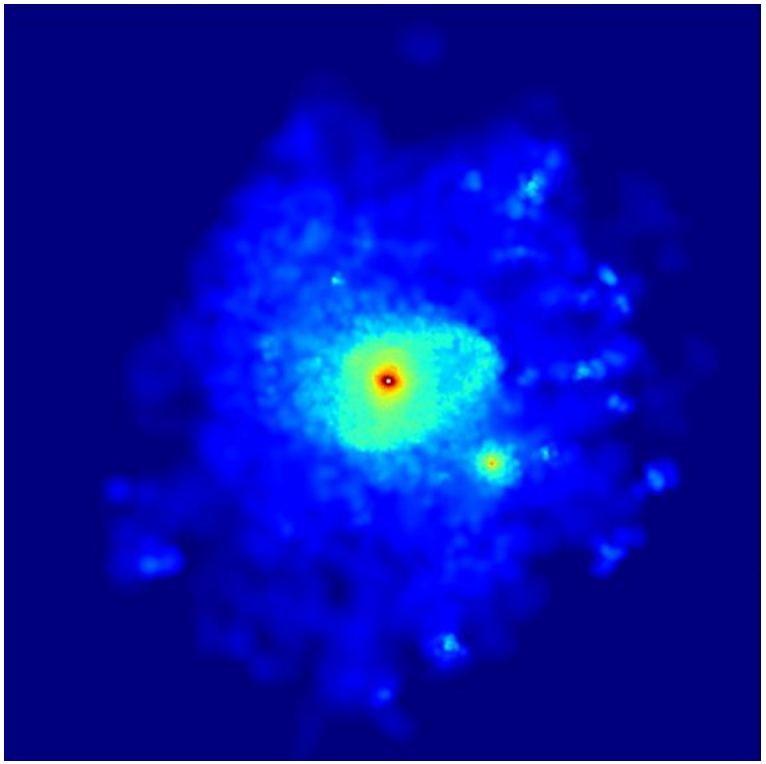
Spheroids galaxies (κ_{rot}<0.5) can form by acretion of gas with diferent aligment of angular momentum or by a major merger event.

Redshift z=0

κ_{rot} = 0.316



κ_{rot} = 0.309



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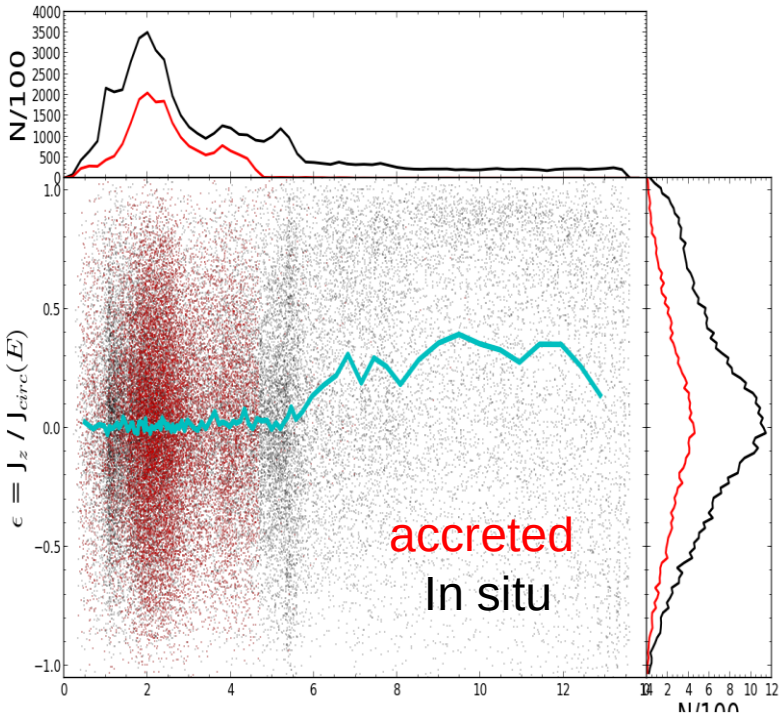

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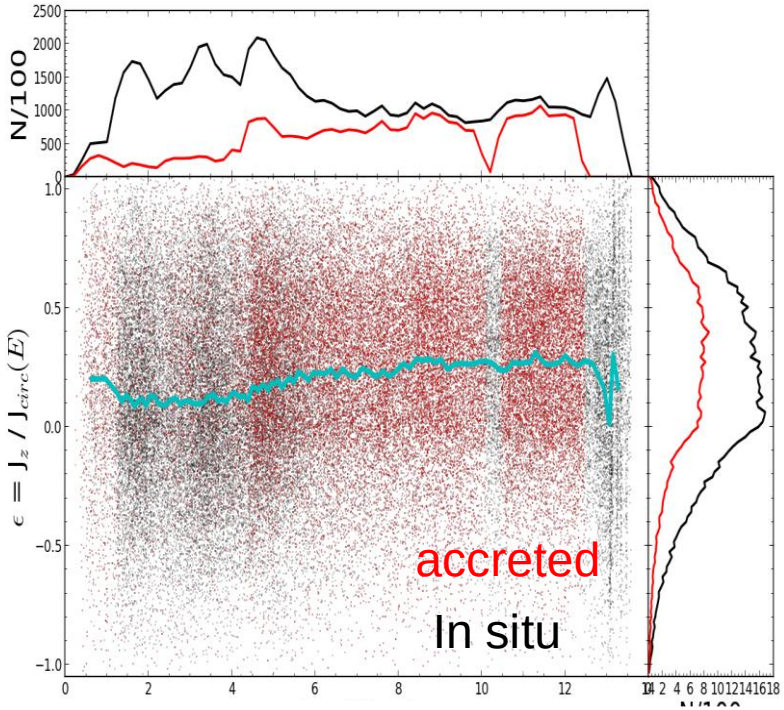


Redshift z=0

Muchas Gracias

The origin of simulated galaxy morphologies

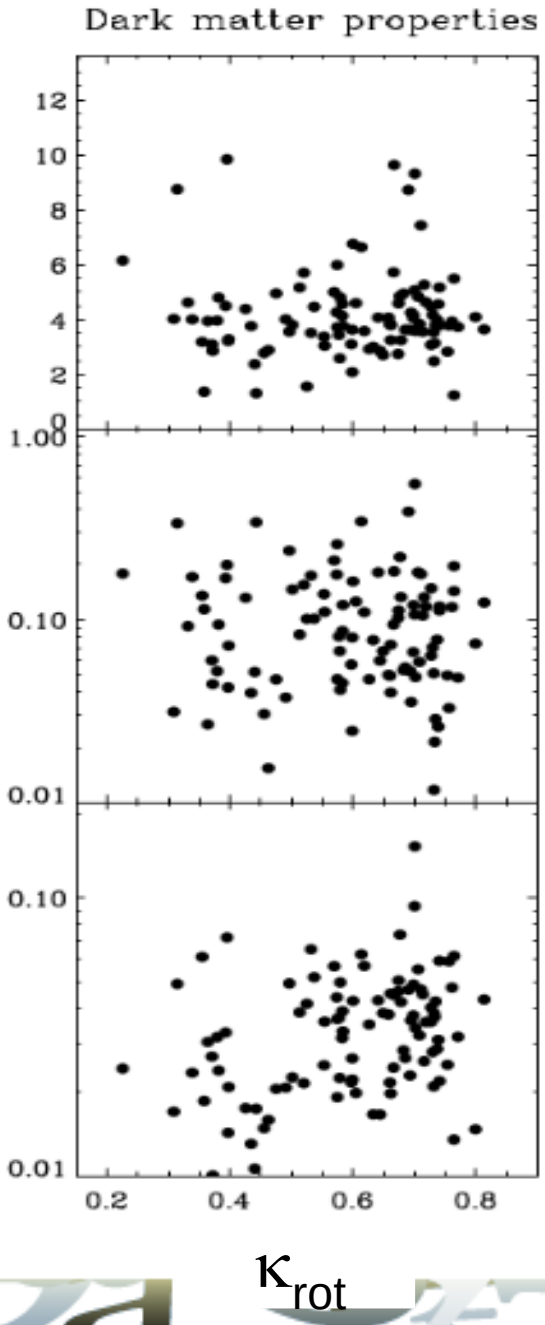
Sales et al. 2012

Half-mass halo formation time $t_{50\%}$

Fraction of halo mass acretted in the single largest merger after z=3 ΔM_{lmm}

Dimensionless rotation parameter λ

$$\lambda' = \frac{1}{\sqrt{2}} \frac{J}{M_{200} V_{200} r_{200}}$$



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"efficiency" parameter

$$\eta_{\mathrm{gal},*} = M_{\mathrm{gal}}/(f_{\mathrm{bar}}\, M_{200})$$

$\eta_{gal,*}$

Fracction of accreted stars

f_{acc}

Fraction of stars that reached born out of gas that went through the "hot phase" ($T_{max} > 10^{5.5}$ K)

f_{hot}